

STATE ENGINEERING EXPERIMENT STATION

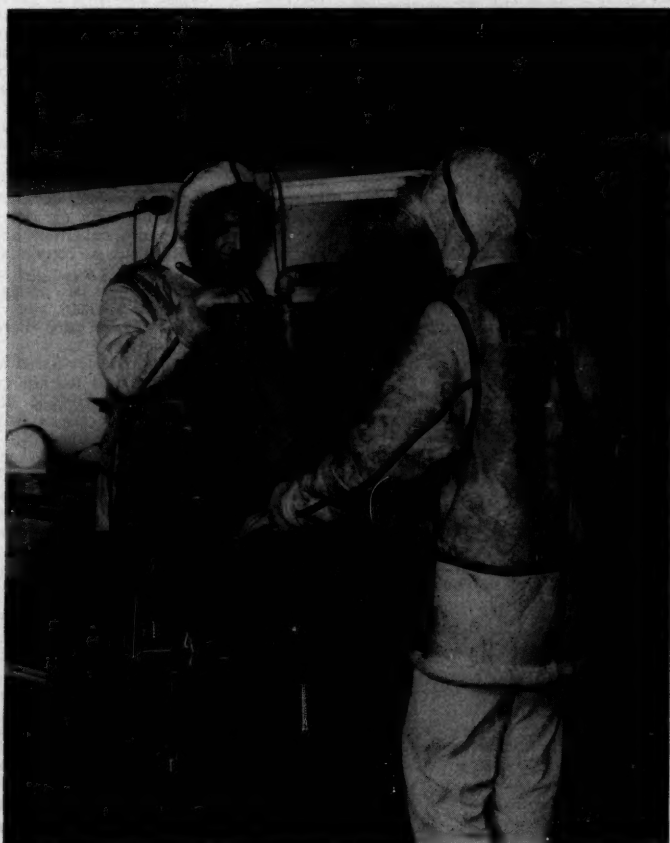
# The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

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# The Research Engineer

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## TELEVISION

To the general public, television seems a cross between radio, the movies, amateur night at the neighborhood theater, Madison Square Garden, the infield of the local ballpark, and a fashion show, wrapped together and served up in equipment so simple that Junior can operate it as well as his father. Those who have sets know full well that television is here to stay; those who do not either wish that they did or ostensibly plan "to wait for a few years until sets are better and cheaper and programs are of higher quality."

Commercial television involves the skillful blending of economics (cost of television equipment, programs, and receiving sets; size of audiences; value to sponsors) with the sciences of electronics, optics, and sound. To achieve its present popularity, compromises have had to be made by all concerned, including the owners of sets, all of whom

obviously could not afford to buy only the best. To expect television to grow to full manhood in the space of one or two years is unfair, even when its lengthy childhood is considered. Those who own sets, however, do not expect it to linger long in the adolescent stage.

To the scientist and engineer, television is equally as fascinating as it is to the layman. Both groups are aware that the present science of television developed slowly and painfully from research extending for several decades; that continued research is in progress; and that future improvements in broadcasting and reception are as certain as anything that man can predict. The layman, however, takes this latter statement for granted; the scientist knows that its attainment means good hard work and plenty of it.

In any case, a new industry has been born, based on science and technology and dependent upon these fields for its continued growth. Dislocations will inevitably occur in other industries—radio, the movies, sports, etc.; some will suffer, some will benefit, all will change. In the end, however, the public will benefit, not only through enjoyment of television but also through the effects on increased employment and its attendant benefits to the nation's economy. The end will have been worth the effort.

"Industrial research" is an abstract phrase which can be variously defined and interpreted. To private industry, it means applied scientific and engineering attention to the solution of problems, the betterment of processes and products, and the development of new items of marketable value.

At a technological institute such as Georgia Tech, "industrial research" is one of several service functions, auxiliary to and of equal

importance to education. Many industries in this and other areas do not have research staffs of their own; many industrial groups desire information which only large-scale research can provide. To these and others who may require its facilities or personnel, Georgia Tech is earnestly striving to render assistance.

BLAKE R. VAN LEER,  
President, Georgia Institute of Technology

## SOME SPECIAL ASPECTS OF TELEVISION

By M. A. HONNELL\*

*The use of television as a new entertainment medium has been so thoroughly publicized during the past few years that many of its other potentialities and general problems are scarcely known to the public. The ability of a television system to transmit a continuous picture of events as they are happening suggests many industrial applications for this new medium of communication. It is the purpose of this article to describe, in brief, some of the most interesting applications of television and some of the special equipment and techniques that have been developed to make television programs available on a nation-wide basis.*

### ULTRAFAX

Television transcription equipment has recently been perfected for the recording of television images on 16-mm film directly from a cathode-ray tube screen. This film may then be employed for rebroadcast purposes, or it may be processed rapidly for projection in a theater only a few minutes after the original scene is televised. The complementary equipment developed for this important technique is a television projector which utilizes standard 16-mm sound motion pictures as a regular source of program material.

A commercially significant development resulting from these methods of film transmission and recording is a rapid system of facsimile called "Ultrafax," recently demonstrated by the Radio Corporation of America and the Eastman Kodak Company. The printed material or sketches to be transmitted are first photographed on 35-mm film. This film is then transmitted over a television system at the rate of 15 frames per second; each frame, of course, consists of a completely different message. At the receiving end, the message is photographed from the face of a cathode-ray tube by use of a special 16-mm camera. The film is developed and dried in less than a minute, after which it may be run through a printing machine to produce enlarged copies of the messages.

Although network facilities are not now available for this method of message transmission, the microwave links and coaxial cable facilities which are being installed for network television broadcasting could be used for Ultrafax transmission after midnight, when regular television stations are off the air. According to this plan, messages would be accumulated and photo-

graphed during the day for transmission during the night. The message-handling capabilities of Ultrafax are on the order of a million words a minute.

### MICROWAVE LINKS

Network facilities for television were recently installed between New York and Boston and New York and Philadelphia, using microwave relay stations located at strategic line-of-sight points approximately 30 miles apart. The network to Boston, installed by the Bell System, consists of four video channels on frequencies about 4,000 megacycles. The Philadelphia network, installed by Philco, provides two video channels on 6,000 megacycles.



Figure 1. A comparison of new and old television "eyes". At left is the iconoscope used in television research at Georgia Tech, while at right is a scanning disc which was used for the same purpose in the School of Electrical Engineering in the 1920's.

\* Professor of Electrical Engineering.



Figure 2. A complete military airborne television station consisting (left to right) of the camera, the transmitter, the connection box, and the generator. Note the portability of such equipment, which weighs a total of approximately 50 pounds.

These microwave systems use frequency-modulated klystron oscillators having an output of from 0.5 to 4 watts. The highly directional antennas employed to beam the signals between the relay stations have a gain of approximately 40 db, or 10,000 as compared to an omnidirectional radiator. The increase in signal strength between the transmitting and receiving antennas, therefore, is enormous. The highly directional characteristics of these antennas reduce interference to a minimum.

There are seven microwave repeater stations and two terminal stations in the 220-mile radio relay route from New York to Boston. This total gives a good indication of the enormity of the problem of providing nation-wide television network facilities. A 2,100-mile relay route would require approximately 70 microwave repeater stations spaced at 30-mile intervals.

#### COAXIAL CABLE

While it is true that the coaxial cable now being installed on a nation-wide basis is capable of carrying television signals, it is doubtful whether all of the present installations can be spared for television service. The repeater spacing of approximately five miles now used on many of the coaxial cable installations restricts the available bandwidth to about 2.5 megacycles, which is too narrow for high-definition television

requirements. Furthermore, the repeater amplifiers now employed cause too much time-delay distortion to permit their use in a coast-to-coast network.

Television signal requirements are such that repeaters may have to be provided at three-mile intervals along the coaxial cable. New tubes have been developed by the Bell System which are suitable for use in these repeaters to provide coast-to-coast television networks. A 2,100-mile coaxial cable network would require approximately 700 repeater stations. This is ten times as many repeaters as is required by a microwave relay link over the same path.

It is difficult to predict, at this time, whether the microwave link or the coaxial cable offers the better solution to the problem of providing television network facilities. Both facilities will be used, initially, wherever they are available. Equally satisfactory television transmission can be achieved over either of these systems, and the choice between them will be based largely on economic considerations.

#### STRATOVISION

The Westinghouse Electric Company and the Glenn L. Martin Company are cooperating on a project of nation-wide television program broadcasting from airplanes. In this "Stratovision" project, it is planned to employ 14 Martin 202 planes flying over key points throughout the nation at an altitude of 25,000 feet. Television programs would be transmitted from plane to plane by means of microwave relays, and would then be broadcast from each plane to cover an estimated circular area of over 200 miles' radius.

The Martin 202 can carry a four-man crew and 7,000 pounds of radio equipment in addition to 1,250 gallons of fuel. This is sufficient fuel to permit the plane to reach its station, remain three hours on station, and, in case of bad weather, fly 200 miles to another field and circle this field for one hour. While the plane is broadcasting, it will cruise at 180 miles per hour in a circle having a radius of 3.5 miles.

Initial Stratovision tests from a converted B-29 have posed many difficult problems which are being solved. For example,

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## A VERSATILE HIGH-SPEED TEMPERATURE RECORDER

By T. W. KETHLEY\* and W. B. COWN\*\*

For use in the research on food freezing being jointly sponsored by the Georgia Tech Engineering Experiment Station and the Tennessee Valley Authority, a system for high-speed recording of thermocouple temperatures over a wide range of temperatures has been devised using inexpensive commercially available equipment. This system is capable of recording, full-scale, temperature ranges as small as  $1^{\circ}\text{F.}$  or as great as  $1000^{\circ}\text{F.}$ ; it has a sensitivity of about one per cent, and it can record temperature changes at chart speeds as high as 0.2 inch per second or as low as 0.75 inch per hour. The time for full-scale response of the system is 1.5 seconds, and the electrical fluctuation of the system is less than 0.5 per cent of full scale at ordinary sensitivities. In addition to the use of this equipment for the recording of temperature changes, the component instruments are capable of being applied to a variety of uses.

Temperature indicators of various kinds are common to every laboratory, but temperature recorders are by no means so often found. In general, this may be attributed to the relatively high cost of recorders and to the fact that most recorders are designed for use in only one type of operation. In other words, the average laboratory simply cannot afford to use recording mechanisms to any great extent because of the amount of money involved in purchasing several recorders, each for a different purpose.

In the experimental work related to studies on the preservation of foods by freezing, now being carried out in the Engineering Experiment Station of the Georgia Institute of Technology, the measuring and recording of temperature changes has been given considerable attention. No single standard-model instrument has been found that is capable of recording temperature changes over wide ranges with the sensitivity, accuracy, and speed that have been desired. The design of instruments whose ranges can be changed quickly and simply is complex, and the cost of construction by a commercial instrument maker was considered prohibitive in this instance.

It was therefore decided to obtain a single recorder and to build or purchase the auxiliary equipment necessary for the vari-

ous operations. This decision was based upon the assumption that one recorder could be used for a variety of purposes and that the auxiliary equipment for these purposes should be relatively inexpensive.

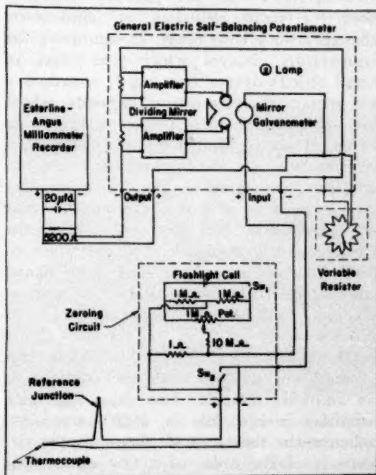


Figure 1. Circuits of "Autopot" (General Electric self-balancing potentiometer) and the auxiliary equipment employed for recording temperature changes.

\* Research Assistant Professor.

\*\* Research Assistant.



### THE RECORDER

Previous experience with recorders had shown that one of the most useful commercial instruments for general use is the high-speed, spring-driven Esterline-Angus 0-1 milliamper d-c recorder. The chart speed of this model can be varied from 0.75 inch per hour to 0.2 inch per second by changing the drive gears, and, being spring driven, the instrument can be moved from place to place regardless of the availability of electric power. This recorder can be used to chart any sort of change that can be converted into d-c milliamperes, such as the output of high impedance amplifiers used to read the changes across glass or other electrodes. It has been used to chart the findings of a continuous analyzer where changes take place in a few seconds, as well as to chart the operational periods of a compressor over a period of 24 hours. In each case, only a simple change in the recorder gears was necessary to obtain the chart speed required to produce a useful record.

In the work at Georgia Tech on the freezing of foods, the primary need has been for rapid recording of temperature changes over a wide range. In measuring the temperature changes which take place in small objects during freezing, it is necessary to prepare thermosensitive elements which are small enough to be located at the center of the object without disturbing the normal relationships of its internal structure. In addition, the mass of the thermosensitive element must be kept at a minimum, so that the quantity of heat required to affect the element will be negligible. The only thermosensitive elements which have been found suitable for the work with frozen foods at Georgia Tech are thermocouples made of No. 30 or smaller wire; this necessary choice of thermocouples for the indication of temperature changes has made the selection of an amplifier difficult. The usual high-gain amplifier circuit has a high impedance, whereas the resistance of thermocouple circuits is of the order of a few ohms. One of the few commercial instruments available as a separate amplifier which is capable of amplifying thermocouple output of the order of microvolts up to amplifier output of milliamperes is a self-balancing poten-

tiometer<sup>1</sup> manufactured by the General Electric Company and referred to as the "Autopot."

### THE AMPLIFIER

The "Autopot" is a versatile instrument which can be used, by changing the value of standardized variable resistors, to indicate emf values as low as microvolts or as high as one volt. It can be used in most cases where an ordinary potentiometer is employed, and the output can be indicated on a milliammeter or recorded on any C-5 milliamper recorder which has a circuit resistance of 1500 ohms or less. In such cases, the "Autopot" acts as a high-gain amplifier which is capable of handling small d-c emf values in low resistance circuits. Because the circuit of the "Autopot" is a self-balancing one, the instrument is not generally affected by variations in the line voltage which drives the amplifiers, except when used at full sensitivity. In this case, there may be as much as five per cent of full-scale variation due to disturbances in unregulated lines; in all other cases, this variation is less than 0.5 per cent of full scale. However, because of the sensitivity of the galvanometer element in the "Autopot," this instrument is very responsive to mechanical vibration and must be isolated from such disturbances by mounting it on a sponge rubber pad.

Details of the "Autopot" and the auxiliary equipment employed for recording temperature changes are shown in Figure 1. The zeroing circuit is one suggested by the General Electric Company to compensate for stray emf, so that the galvanometer can be brought to zero simply and quickly. The output of this circuit is approximately 100 microvolts, which is sufficient to compensate for normal variations. Switch 2 shown in Figure 1 is a shorting switch which is employed to cut the thermocouple out of the circuit and thus allow the proper location of the zero of the "Autopot" and of the recorder. The 20-microfarad condenser across the recorder is necessary to smooth

<sup>1</sup> R. H. Muller, *Industrial and Engineering Chemistry, Anal. Ed.* 18, No. 9, 23A (1946).

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## GEORGIA TECH PARTICIPATION IN THE OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

By R. L. SWEIGERT\*

*"Nuclear studies," "Oak Ridge," "atom bomb," and many similar phrases have commanded much attention in recent years. The following article describes the manner in which Georgia Tech is participating in a broad educational and research program intended to develop knowledge in this field and to train advanced scientists.*

Since the revelation of the employment of the atomic bomb at Hiroshima, the term "nuclear studies" has been chiefly associated in the popular mind with the use of nuclear energy for military purposes. Scientific personnel have, of course, long realized that such studies might serve as a key to unlock a veritable storehouse of fundamental knowledge, much of which would eventually be of material benefit to mankind. It remained, however, for a group of Southern university personnel working at Oak Ridge, Tennessee, to realize that full utilization of the magnificent staff and facilities of the plants located there could best be utilized for the advancement of scientific knowledge by the integration of their future work with research programs already developed by existing universities. Shortly thereafter, the Oak Ridge Institute of Nuclear Studies, now sponsored by 19 Southern universities, embarked on a broad training and research program in the field of nuclear studies.

Georgia Tech is one\*\* of these sponsoring institutions, and it is vitally concerned with and interested in both the research and the educational activities of the Oak Ridge institute, since its participation provides an opportunity to contribute more effectively to the provision of needed engineering and scientific workers for the fields of nuclear research and operations. In addition, participation in these activities will give Georgia Tech personnel continued access to facilities which not even the wealthiest

universities can afford to provide, since their cost is reckoned in the millions of dollars.

### AVAILABLE FACILITIES

Available facilities include the Oak Ridge National Laboratory and the research laboratories of the installations operated by the Carbide and Carbon Chemical Corporation for the Atomic Energy Commission, namely, the gaseous diffusion and the electromagnetic plants for the production of Uranium 235. Equipment available in these laboratories include the uranium-graphite pile, which is the principal instrument of the National Laboratory, and a host of comparatively minor pieces such as beta ray and neutron spectrometers, cloud chambers, counters, and coincidence circuits.



Figure 1. The gas diffusion area at Oak Ridge, Tennessee. This plant for the separation of uranium isotopes contains associated laboratories which present unique opportunities for research in a number of fields, laboratories which are available to Georgia Tech scientists through the Oak Ridge institute's programs.

\* Dean of Graduate Studies.

\*\* Others are Alabama Polytechnic Institute, Catholic University of America, Duke University, Emory University, Louisiana State University, Tulane University, Vanderbilt University, and the Universities of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisville, Mississippi, North Carolina (including State College at Raleigh and the Woman's College at Greensboro), Texas, Tennessee, and Virginia.

## GEORGIA TECH PARTICIPATION

There are four ways in which Georgia Tech may share in the activities of the Oak Ridge Institute:

1. Through the graduate training program.
2. Through having Georgia Tech faculty members spend time, usually three months to a year, at the Oak Ridge National Laboratories, and through permitting faculty members to attend special conferences and programs at Oak Ridge.
3. Through research projects to be carried on at Georgia Tech.
4. Through having engineers and scientists from Oak Ridge visit Georgia Tech, delivering lectures and perhaps eventually spending a term on the campus giving graduate instruction in and directing research related to the nuclear field.

## GRADUATE TRAINING PROGRAM

The graduate training program mentioned above is an arrangement whereby a candidate for a doctorate degree in chemistry, physics, biology, mathematics, or engineering can complete practically all of his course work on the campus and then go to the Oak Ridge laboratories to perform his thesis research. Thus, the Oak Ridge installation becomes part of the facilities available for advanced students at Georgia Tech, and excellent research men on the Oak Ridge staff become available as auxiliary members of the Georgia Tech staff. However, it should be emphasized that the Oak Ridge institute itself does not grant degrees. Thus, Georgia Tech will grant degrees to those of its students who are approved for Oak Ridge fellowships, provided, of course, that they successfully meet all other requirements for the degree. Incidentally, the research program of these students will be carried out under the direction of regular members of the Georgia Tech faculty.

The research problems that are open to properly qualified students are almost too numerous to name. The uranium-graphite pile can be used for the irradiation of physical and biological samples; for the production of radioactive materials; as a source of neutron beams for scattering, absorption, and neutron diffractions; and for many other experiments. There are many engineer-



Figure 2. Aerial view of the electromagnetic separation area at Oak Ridge, Tennessee. This area also contains laboratories which present many opportunities for research.

ing problems in the chemical and metallurgical fields; these include exceptionable opportunities for studies in physical metallurgy and corrosion of light metal and nonferrous alloys. The metallurgical problems peculiar to the nuclear reactor development, of course, are legion. Theoretical studies of the phenomena of solvent extraction and radiochemical separations may be made, as may investigations involving heat transfer. Other fields in which programs may be carried on are: raman, infrared, microwave, optical, mass, and X-ray spectroscopy; X-ray and electron diffraction; gaseous self diffusion; diffusion in solids and adsorbed films; the determination of mechanical, electrical, and thermal properties; vapor pressure determinations; determination of the effects of radiations on chemical reactions; fluorine chemistry; and electronics. Lastly, there is a project under way in which the use of nuclear energy for the propulsion of aircraft is being investigated; this project alone offers many interesting challenges.

## FACULTY PROGRAM

As mentioned, interested faculty members may spend varying periods of time at the Oak Ridge institute. The purpose of such visits may be to attend conferences such as the one which was recently conducted to provide training in radioactive techniques for research personnel, or to participate actively

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## ANTIOXIDANTS FOR OILS AND FATS \*

By E. P. COFIELD, JR.\*\* and L. L. ANTLE\*\*\*

*Annual losses incurred by the processors of oils and fats as well as oil- and fat-containing foods through the appearance of rancidity, a condition recognized by its accompanying objectionable odor and taste, run into thousands of dollars. These losses are being reduced through the use of substances known as antioxidants, which tend to retard the appearance of rancidity and thus to increase the shelf life of many foods. The following article lists a number of factors which tend to promote the appearance of rancidity, describes several tests which are used to determine whether or not an oil or fat is rancid, and discusses a number of theoretical and practical aspects of the use of antioxidants.*

In the marketing of many foods, considerable periods of time elapse between the processing of the food and its eventual consumption. If these foods are to receive favorable customer reception, however, it is always highly necessary that they retain a "fresh" taste for as long a time as possible.

For certain foods, such as potato chips, salted nuts, and fried noodles, obtainment of a reasonably long shelf life is particularly difficult. This is occasioned in part by the fact that such products are frequently packaged in relatively light, flimsy containers that are neither light- nor air-proof, but the primary difficulty is inherent in the method used to prepare these foods; namely, frying in deep fat.

The fats (lard, edible tallow, and stearin) and vegetable oils (cottonseed, corn, peanut, and soybean) used as deep-frying mediums are mixtures of relatively complex organic compounds which, in common with a majority of organic compounds, are subject to deterioration. In the case of oils and fats, this deterioration, which may be caused by a number of factors, will in general follow one or both of two courses. The first of these, hydrolysis, involves the splitting of the oil or fat molecules into what may be thought of as the compounds from

which they were originally formed, fatty acids and glycerine. The other, oxidation, includes a complicated series of reactions which ultimately result in the condition commonly referred to as rancidity. Of these two courses of deterioration, prevention or minimization of the oxidation reaction is by far the most important to processors of oil- or fat-containing foods.

The enormous losses that are incurred each year in the food industry by the appearance of rancidity have made this matter the subject of wide-spread study, one of the primary objects being the development of methods to decrease such losses. One method which has shown considerable promise and which is now much employed is the use of substances known as antioxidants.

## RANCIDITY

"Rancid," "stale," or "reverted" oils and fats are those which have developed an objectionable odor and taste, variously described as pungent, tallowy, soapy, oily, esterlike, metallic, musty, fishy, bitter, cardboard, and burnt.<sup>10</sup>

## Chemical Reactions

Although an immense amount of research has been performed in an attempt to determine the nature of the chemical reactions that eventually cause fats and oils to become rancid, much of the evidence that has been obtained is contradictory in nature. This is occasioned by a number of factors, not the least of which is the fact that the ultimate standards to which all data must be referred are essentially subjective; namely, the senses of smell and taste.<sup>2</sup>

\* This article is a slightly modified version of a brief literature survey on the use of antioxidants for the preservation of oils and fats, prepared for The Woodman Company Inc. by the Technical Information Division of the Georgia Tech Engineering Experiment Station.

\*\* Research Assistant, Technical Information Division, Georgia Tech Engineering Experiment Station.

\*\*\* Vice-President, The Woodman Company Inc., Avondale Estates, Georgia.

It has been established, however, that the appearance of "off" flavors in fats and oils is caused either by the action of oxygen or by fungi with which the material has become inoculated,<sup>6</sup> the most common cause undoubtedly being the action of oxygen. Experimental data also indicate that the oxidation reaction which eventually results in rancidity consists of two distinct phases. The first of these phases is known as the induction period, and, although the fat or oil is actually deteriorating during this period, it retains a "fresh" odor or taste and, of course, does not exhibit the characteristics commonly associated with rancidity. It has been established that the oxidation reaction proceeds very slowly while in the induction period.

At the onset of the second phase, however, the rate of oxidation increases rapidly. A very rough analogy to this phenomenon would be the sudden bursting into flame (rapid oxidation) of an oil-soaked rag (in which slow oxidation has been heretofore proceeding). The point at which the fat or oil begins to smell and taste rancid coincides with the beginning or early part of the second oxidative phase.<sup>7</sup>

#### Influencing Factors

The rate at which a fat or oil will react with oxygen or, similarly, with the atmosphere tends to vary in accordance with a number of conditions, some of which may be established during the original processing of the material; for example, during the refining. Numerous factors which are collectively referred to as pro-oxidants are known to accelerate oxidation, thereby decreasing the duration of the induction phase. These may be classified, for purposes of convenience, as primary factors and as contributory factors. The primary factors are the action of metals and light, while the influences of moisture, temperature, and photosensitizers may be numbered among the contributory factors.<sup>8</sup>

The role played by metals in the packaging and processing of fats and oils is obviously an important one, as it is well known that metals and metallic salts accelerate the oxidation of such substances. Copper is the worst offender, followed by lead, iron, zinc, nickel, cobalt, chromium, and manganese, although not necessarily in

that particular order.<sup>4</sup> As mere traces of these metals (particularly copper and iron) suffice to catalyze oxidation, the kinds of metals employed in the fabrication of oil processing machinery and containers for oils and fats obviously assume considerable importance. Tin and aluminum, incidentally, appear to be quite inactive<sup>4</sup> and may therefore be used either to coat or to replace the more active metals.

As mentioned, light is also an important factor. It has been found that even brief exposure to direct sunlight is sufficient to accelerate the eventual oxidation of an oil or fat. This effect is rather insidious, since its results are not immediately apparent; once oxidation has been initiated, subsequent storage of the product in the dark does not arrest the development of rancidity.<sup>4</sup>

In order for light to play an active part in producing a change in an oil or fat there must be present a photosensitizer which acts as a light absorber.<sup>4</sup> Chlorophyll, a substance present in virtually all plants, has been suggested as one photosensitizer that might well be present in most vegetable oils, and the results of a considerable amount of experimental work seem to support this hypothesis. The probable role of the photosensitizer, that is, as an absorber of energy, has also been substantiated by experiments in which it was demonstrated that the development of rancidity was accelerated more by the ultraviolet, violet, and blue portions of the spectrum than by the red or yellow portions; the green portion exerted even less influence than did the red and yellow.<sup>4</sup>

Knowledge on the effect of moisture on the oxidation of fats is somewhat contradictory. The results of some investigations have indicated that moisture exerts a slight retarding effect upon the rate at which the fat may be oxidized. However, the presence of moisture in fats and oils is known to permit the growth of powerful enzyme systems that are capable of accelerating oxidation. It has been shown that 0.3 per cent moisture is sufficient to permit the growth of bacteria and molds.<sup>20</sup>

It is well known that the exposure of hot fats and oils to the atmosphere serves to decrease their stability. Although rancidity does not normally appear as long as an elevated temperature is maintained, the keeping qualities of an oil or fat which has been

used for deep frying is seriously impaired.<sup>1</sup>

Although the nature of the pro-oxidant was not determined, the results of a recent investigation indicated that many paper containers exert an adverse effect upon the keeping qualities of oil and fat products stored therein. This finding, along with means for alleviation of the problem involved, should be of particular interest to processors of fried foods.<sup>2</sup>

### Tests

A number of tests have been devised to determine the extent to which oils or fats have become oxidized and to serve as a basis for estimating their relative keeping qualities. Inasmuch as the presence of rancidity is normally indicated by an "off" flavor or odor, at least insofar as customer acceptance of any given product is concerned, it is obvious that such tests will have little practical value unless their results can be correlated with rancidity determined by organoleptic (sensory) means. Although the course of the chemical reactions that occur when an oil or fat is oxidized is not well understood, it is generally recognized that peroxide type compounds are formed. Therefore, many of the tests that have been devised are based upon a determination of the peroxide content of a sample under a given set of conditions.

A number of tests, probably the most widely used of which is the procedure developed by Kreis,<sup>10</sup> are now available for determining the state of oxidation at the time the test is made. However, such tests give no indication relative to the time that will elapse before an oil or fat become organoleptically rancid; therefore, they cannot be used for estimating keeping qualities.

An "active oxygen test" is now employed by a majority of laboratories for estimating keeping qualities or the shelf life of oils and fats.<sup>12</sup> In this test, which is also known as the Swift stability test, samples are aerated at elevated temperatures, and organoleptical methods are used to determine when rancidity becomes apparent. The peroxide content of the sample is then obtained by chemical analysis, and the results of this analysis are expressed as the peroxide value of the oil or fat. This value varies with different substances; lard and hydrogenated cottonseed oil have values of

20 and 75, respectively. The keeping quality of the fat is expressed as the total number of hours of incubation (hours, AOM) required to produce the peroxide value of the material under study.

Another test that is frequently employed in estimating the relative keeping quality of fats and oils is the Schall test.<sup>13</sup> This test is of considerable value, since it can be applied to fats or oils that have been incorporated in various foods, such as potato chips. It is essentially an organoleptic procedure with the results being expressed as the number of hours (or days) required for the fat to become rancid under the test conditions.

It should be emphasized, however, that such tests are designed to give estimates only and, therefore, are not "foolproof"; accordingly, their results should be checked by comparison with the results of actual shelf life tests whenever possible.

### ANTIOXIDANTS

As previously mentioned, rancidity is the result of a series of complex oxidation reactions which may be divided into two phases, an induction period and a period of rapidly accelerating oxidation. It has also been shown that the initiation of the latter period marks, for all practical purposes, the appearance of organoleptic rancidity.

It is a well-recognized fact that the keeping qualities of highly refined oils are inferior to those of crude oils. The logical inference that some substance which inhibited the oxidation of the oil is removed during the refining process was substantiated when a compound known as tocopherol was isolated from a number of vegetable oils.<sup>1</sup> This compound proved to be an effective antioxidant, particularly when added to animal fats.<sup>10</sup>

The mechanism by which an antioxidant prolongs the induction period of a fat or oil is not completely understood, although a number of experimental facts have been determined. One of these is that an antioxidant must be an acceptor of oxygen, that is, it must be capable of being oxidized. Thus, it appears that, in protecting an oil or fat from the deleterious effects of oxidation, the antioxidant is subjected to preferential oxidation.

A review of the experimental work in the antioxidant field which has been carried out during the past few years indicates that, while very satisfactory results have been obtained in a number of instances, clear-cut conclusions are rare. The field is complicated by difficulties in assaying and interpreting results. Compounds which prove to be effective antioxidants under one set of conditions appear to be ineffective in a different environment. For example, compounds that are effective in the presence of light may fail to function in the dark, and, in a like manner, substances that give satisfactory results at room temperature may prove to be ineffective at elevated temperatures.<sup>10</sup> Thus, accelerated keeping-quality tests, which are made at elevated temperatures, may give misleading results. The only way to determine the effectiveness of an antioxidant is to test the oil or fat thus stabilized under the conditions in which it is going to be used.<sup>12</sup>

#### Synergists

One of the more important results of recent experimental work was the discovery that, in some instances, the combination of an antioxidant with another compound which is not necessarily an antioxidant gives surprisingly good results. These latter compounds are known as synergists, and their reinforcing action is commonly referred to as a synergistic antioxidant effect. The mechanism by which this effect is accomplished is not thoroughly understood, as in the case of the simple antioxidant effect. However, the results of an investigation into the synergistic action of ascorbic acid with tocopherol indicated that while the ascorbic acid alone was not able to stabilize a fat, it was capable of retarding the oxidation of the tocopherol, which in turn prevented the oxidation of the fat.<sup>10</sup> Ascorbic acid has been reported as being very effective in the stabilization of peanut butter. In this particular case, it was not determined whether the ascorbic acid functioned as a primary antioxidant or as a synergist to some unknown but naturally occurring antioxidant.<sup>11</sup>

Inasmuch as the American public has always demanded a vegetable oil that was practically flavorless and odorless, such oils that are marketed are highly refined products.

Because of this, much of the protection originally supplied by nature in the form of antioxidants such as the tocopherols is lost. In an effort to improve the keeping qualities of these highly refined oils, and of food prepared from such oils, a considerable amount of research has been conducted on the development of antioxidants for addition to or use with these oils.

#### Desired Properties

The American Meat Institute Foundation has listed the properties of the ideal antioxidant as follows:<sup>7</sup> (1) it should contribute no objectionable flavor, odor, or color to the fat; (2) it should be nontoxic; (3) it should be readily fat soluble; (4) it should be effective in low concentrations; (5) it should be readily available in adequate amounts; (6) it should "carry through" and effectively protect from rancidity the foods made with the fat; and (7) it should be reasonable in cost.

In the development of antioxidants for use in edible products, naturally occurring materials, particularly materials derived from food sources, have been extensively investigated, since it was considered unlikely that such products would be toxic. As a result of these investigations, the use of a number of substances has been patented, among which are fractions distilled from vegetable oils, gum guaiac, cereal flours, lecithin, and cottonseed meal.<sup>9</sup>

However, antioxidants obtained from other sources have proved more effective. Compounds containing free hydroxyl groups have shown the most promise, a behavior that had been indicated by the results of investigations on naturally occurring antioxidants. To list only a few, tartaric, citric, ascorbic, lactic, glycolic, and maleic acids; glycerol; various sugars; alkyl gallates; pyrogallol; and butylated hydroxyanisole have all exhibited antioxidant properties.<sup>7, 8, 10, 11</sup> Pyrogallol was particularly effective in inhibiting the oxidation of fats stored in paper containers.<sup>2</sup>

Naturally, no attempt can be made here to cite all of the experimental data which have been accumulated in studying the effect of adding antioxidants to oils and fats. In

*Continued on Page 24*

## DIGESTS OF GRADUATE THESES

## ELECTRICAL ENGINEERING

1947-1948

The following digests represent summaries of theses submitted during 1947-48 in partial fulfillment of the requirements for the degree of Master of Science in Electrical Engineering. This is the third in a series of features designed to present data on the graduate theses submitted last year to the various schools of the Georgia Institute of Technology.

Hugh Austin Brown, *Theoretical and Experimental Study of Wave Forms of Transformer Supplying Mercury-Arc Rectifier*. Faculty advisor: Professor D. P. Savant.

David C. Prince and Francis B. Vogdes, in their 1927 book on *Principles of Mercury-Arc Rectifiers and Their Circuits*, have attempted to show by use of mathematics the currents and voltages which should flow in rectifiers and in transformers feeding them.

The purpose of this thesis study was the solution of the formulas published by Prince and Vogdes as they regard transformers connected delta on the primary side and star on the secondary and, secondly, the comparison of the theoretical results obtained from their work with data actually obtained from experimental tests. In order to conduct the tests with a polyphase circuit, it was necessary to use an ignition rectifier, but the results obtained from the use of this rectifier as compared with those obtained from any other type of polyphase mercury-arc rectifier should not differ for the purpose of this work.

The experiments conducted proved that the analysis of Prince and Vogdes is not correct when applied to a mercury-arc rectifier fed by three single-phase transformers connected straight delta-star; their mathematical derivations are true only for transformers whose secondaries are interconnected, or zig-zag. The primary wave shapes for both line and phase are correct for a three-phase transformer connected delta on the primary and star on the secondary, and for three single-phase transformers connected delta-zig-zag, but their wave shapes are incorrect for single-phase transformers wired straight delta-star. These conclusions were borne out by mathematical analysis and by photographs of the actual waves obtained from the tests. M.B.

William T. Clary, Jr., *Optimum Operating Conditions of a Multi-Grid Frequency Converter*. Faculty advisor: Dr. W. A. Edson.

An important unit in any superheterodyne receiver is the converter or mixer. This unit comprises the circuit in which the incoming signal of any frequency within the band is converted to give a constant output frequency, which is termed the intermediate frequency and is the frequency to which the fixed radio frequency (or intermediate frequency) amplifier is tuned.

This thesis was undertaken in an attempt to correlate and unify existing work on converters and to offer to the engineer, who must use them in the field, recommendations as to their optimum operation.

The operation of a frequency converter may be completely described from a knowledge of the complete static characteristics of the converter tube. The output may be calculated by either of the two methods presented in this thesis, the "variational conductance" method or the "empirical exponential equation" method. Accuracies obtainable by the two methods are comparable. The method of an empirical equation possesses the advantage of giving a more complete final result, although it has a serious disadvantage in the amount of work necessary to obtain the empirical coefficients.

The conditions for optimum operation of a multi-grid frequency converter are briefly as follows: (1) a value of signal grid bias which gives the maximum slope of the static transfer characteristic should be employed, (2) the class of operation should be B or C, (3) the oscillator grid should be driven positive the maximum amount allowed by the tube ratings, (4) the signal voltage should be small enough to allow operation over the linear portion of the signal grid transfer characteristic, and



(5) other tube electrode potentials should be as recommended by the tube manufacturer.

The above recommendations in general apply to all converters which use an inner grid for the oscillator and an outer grid for the signal. With slight modifications, the recommendations also apply to other vacuum-tube converters. *M.B.*

*Isadore Cogan, Development of a Linear Recording Meter. Faculty advisor: Professor M. A. Honnell.*

Since the beginning of World War II, automatic recording and controlling instruments have been widely used. Of all the instruments developed to date, however, the servomechanism type has become most popular. Although the use of this word "servomechanism" in the engineering field is relatively new, the field of automatic control which the term covers is far from new.

The purpose of this study was the design, construction, and analysis of a recording instrument of the servomechanism type, the graphic linear recording meter. This instrument, aside from its linear recording characteristic, has the following features: (1) high input impedance, (2) error less than five per cent, and (3) ability to record on polar coordinate paper signals of 0-10 volts, charging up to a rate of one cycle per minute. With slight modifications in design, the meter can readily be used as an automatic control device.

One immediate application of this recording meter is in plotting a polar diagram of the radiation pattern of model antennas. Also, it may be employed in connection with an antenna pattern calculator whose output is a modulated 60-cycle sine wave. *M.B.*

*Charles Edward Durkee, Transient Response of Compensated Video Interstages. Faculty advisor: Dr. W. A. Edson.*

This study was concerned with the presentation of the results of square wave tests on most of the high-frequency compensated interstage networks which appear in the literature, in addition to information which will facilitate the design of a network to meet prescribed engineering requirements. To simplify the experimental work, it was decided to start with an amplifier capable of faithful reproduction of the square wave used. Distortion was then deliberately introduced by the addition of accurately

known amounts of shunt capacitance. The use of relatively large shunt capacitance made it possible to use signal frequencies low enough to eliminate the effects of all actual stray capacitances existing in the amplifier. Thus, all factors involved in the problem were accurately controlled.

From the experimental results, it is evident that the degree of improvement in performance afforded by the more complex networks does not, in every case, justify their use. The selection of a configuration for a particular application depends upon the specifications to be met. It may easily be true that a very simple interstage will perform creditably enough to meet the requirements at hand; i.e., it does not follow that a complex network will always give better results than a simpler one. With this idea in mind, a procedure was set up for designing a video stage to amplify sharp pulses, in accordance with a given set of specifications. *M.B.*

*Daniel Curtis Fielder, Analysis of Wideband Phase-Shift Networks. Faculty advisor: Professor M. A. Honnell.*

In 1946, three variations of a circuit for producing  $90^\circ$  difference of phase shifts and a constant amplitude of voltage over a specified frequency band were described by R. B. Dome in an article entitled "Wideband Phase-Shift Networks" (*Electronics* 19, 112-15 (1946)). Through use of this circuit, a  $90 \pm 4^\circ$  phase difference is obtained over the frequency band from 130 to 3000 cycles per second. While the phase characteristic is not quite as desirable as that obtained in some other systems, Dome points out that a more critical choice of circuit parameters will reduce the variation from a true  $90^\circ$  phase shift. Moreover, this circuit has one distinct advantage over earlier ones, i.e., the output remains constant over the desired frequency range.

It was the purpose of this thesis study to analyze the three types of networks described by Dome, to extend the range of two, and to construct an experimental model based on the results of the extension.

The close agreement between calculated and test results indicates that the extended form of the Dome R-C network is entirely practical for use as a producer of a  $90^\circ$  phase difference over a wide audio range. Further, since the calculated error of the ex-

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tended network is less than the calculated error of Dome's single critical frequency network, the frequency range has been increased and the accuracy has also been improved.

This work is important because it permits the construction of a single-sideband transmission system which requires no filters and is accordingly light, compact, and inexpensive. *M.B.*

Donald Woodrow Fraser. *Construction of Apparatus for Microwave Testing in the Three-Centimeter Region.* Faculty advisor: Dr. W. A. Edson.

The primary objective of this project was to construct apparatus which delivers the required exciting and modulating voltages to three-centimeter oscillators. It was therefore necessary to determine the voltage and current waves required for the desired tests and demonstrations and to incorporate in the apparatus voltage supplies and circuits which would furnish these in a manner convenient for the operator.

A secondary objective was to describe processes of microwave testing and demonstration which would be valuable to microwave studies. In practice, the testing of microwave components and the demonstration of their properties is a natural objective. In this project, however, the techniques of such testing and demonstration have served principally as a guide to apparatus design.

The apparatus constructed permits speech communication by means of frequency or amplitude modulation as well as testing by means of square waves and frequency modulated waves. It is portable, to facilitate field testing or demonstrations. *M.B.*

William Benjamin Jones, Jr.. *A Screen-Grid Coupled Direct-Current Amplifier.* Faculty advisor: Dr. W. A. Edson.

Direct-current amplifiers are required in circuits when the signal to be amplified is of zero or very low frequency. The purpose of this work was the investigation of the possibilities of screen-grid coupling in d-c amplifiers and the development of an amplifier employing this type of coupling.

The author reviewed the literature on direct-coupled amplifiers with particular emphasis on the problems arising from drift and interstage coupling. The theory of screen-grid coupling was then discussed, followed by a detailed discussion on the design

of the amplifier, which was constructed and tested. From the results of the tests made, the author concluded that the use of screen-grid coupling in a d-c amplifier had been successfully demonstrated and suggested several refinements for incorporation into any such amplifiers that may be constructed in the future. *E.P.C.*

John Quinn Kessinger. *A Mathematical Analysis of a Three-Phase Induction Motor, Operated Three-Phase and Single-Phase with Unbalanced Rotor Conditions.* Faculty advisor: Professor D. P. Savant.

A balanced three-phase voltage applied to a circuit may be considered as consisting of positive and negative phase sequence components. Of course, the negative sequence voltage will be zero, but it is carried through symbolically in the development of the theory. The same theory may then be applied to a rotating machine when operated single-phase as when operated three-phase.

Much theoretical work has been done on induction motors, but the method of analysis employing symmetrical components best suits the particular problem at hand, and this theory was used throughout the thesis.

The purpose of this thesis was the comparison of the results obtained by mathematical analysis with actual laboratory tests on a three-phase induction motor operated three-phase and single-phase with unbalanced rotor conditions. *M.B.*

Howard Lindsay McKinley. *A Radio-Frequency Noise Survey in Atlanta and Vicinity.* Faculty advisor: Professor M. A. Honnell.

The purpose of this radio-noise survey was to determine the noise-field strengths at various locations in and near Atlanta and to develop a technique for making these measurements with commercial equipment.

A review of the literature indicated that there was no record of a previous survey of this type. However, this review did reveal some interesting methods which had been utilized for making this type of measurement, as well as the methods by which such measurements were analyzed. The equipment employed was described in this thesis, as was the operating technique employed. The data obtained were analyzed, and it was concluded that radio noise, on the frequencies tested, was of local nature and was of sufficient magnitude in many loca-

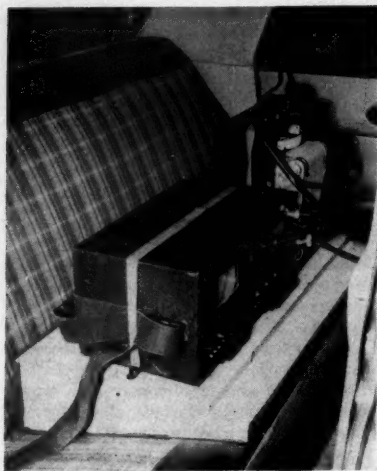


Figure 1. Noise intensity meter employed in making radio noise survey of Atlanta and vicinity by Howard Linsey McKinley.

tions to cause serious interference to television services in this area. *E.P.C.*

John Laurence Markwalter, Jr., *A System of Noise Reduction Employing Two Amplitude Modulated Carrier Waves*. Faculty advisor: Dr. W. A. Edson.

In all kinds of radio communication systems, noise has always been a topic of great concern. The purpose of this investigation was to devise a system of amplitude modulation which, for a given received signal intensity, will have a greater signal-to-noise ratio than the conventional amplitude modulation system used in commercial radio broadcasting.

The system devised employs two carrier waves differing in frequency and modulated in phase opposition to each other. The two signals are received in individual receivers, and the resultants of modulation frequency are combined differentially to restore the original signal. It is through the differential connection of receiver outputs that a reduction of impulse noise over that of the output of either receiver is effected. Two methods of amplitude modulating the carrier wave are described. In one, the individual carrier waves are identical with those of the conventional amplitude modulation system. In

the other, the amplitude of the carrier frequency component of the transmitted wave varied in direct proportion to the amplitude of the modulating wave. An experimental system operating over a short distance and employing low transmitted power was used to demonstrate the properties of this system. A considerable noise reduction giving a reasonable check on that predicted was observed. *E.P.C.*

John Laurin Martin, *Solution of Relay and Switching Circuits by Symbolic Analysis*. Faculty advisor: Dr. W. A. Edson.

Problems involving complicated systems of relays and switches are frequently encountered in all those phases of industry which employ electric control circuits and protective relay systems. Although the literature available on this subject is not extensive, a method of solving relay and switching problems has been introduced by Shannon<sup>1</sup> which uses the principles of symbolic logic.

In the development by the student of an analysis for certain types of circuits, the lines of Shannon's paper were followed; however, ordinary direct current circuit theory was used as an approach rather than symbolic logic, because of the unfamiliarity of most industrial personnel with symbolic logic.

In this approach, the first step was a study of the simplifications in the theory of simple electrical circuits which result from the assumption that a circuit impedance may have only two values, zero or infinity. A relationship between these simplified equations and symbolic logic was then introduced, and an algebra developed that facilitates the reduction of complicated circuits. This was followed by a discussion of the synthesis of networks, with particular attention being devoted to the symmetric function circuit. Precautions that should be observed in applying this theory to actual problems were determined by a series of laboratory experiments.

As a result of this study, it was concluded that the solution of any relay or switching problem that can be approached

<sup>1</sup> Claude E. Shannon, "A Symbolic Analysis of Relay and Switching Circuits," *AIEE Transactions* 57, 713-23 (1938).

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from the open or closed circuit viewpoint is aided by the proper application of the theory presented. However, as practical limitations and extensions to the application of this theory cannot be readily recognized from theoretical solutions, laboratory experiments must be employed for their verifications. *E.P.C.*

Earl Arden Miller, *A Low-Frequency Saw-Tooth Generator*. Faculty advisor: Professor M. A. Honnell.

In the modern high-vacuum cathode-ray tube, science has available an excellent instrument for the measurement and observation of phenomena of an electrical nature or of such a nature that they can readily be translated into electrical or magnetic effects. However, to be used conveniently, the cathode-ray tube must be incorporated in an oscilloscope circuit which has several functions, one of which is to provide a deflection voltage, or sweep, that varies with respect to time in some known fashion, usually linearly. Although saw-tooth generators capable of producing relatively high-frequency sweep circuits are quite common, there are few references in the literature to sweep generators capable of operating at frequencies of the order of a few cycles per second. In view of the recognized need for a linear saw-tooth generator that would produce a sweep having a frequency range between one and thirty cycles per second, this investigation was undertaken.

Although a number of methods for producing the desired voltage are discussed, it was decided in this instance to employ a capacitor charged through a thyatron and discharged through what is effectively a very high resistance. By the proper application of negative feedback it was possible to effectively linearize the sweep obtained from this source. The circuit design that was ultimately used is shown, and the experimental development of this circuit is discussed, including the methods used to accomplish fine and coarse frequency control.

The author concludes that it is possible to build a saw-tooth generator employing a relatively simple circuit for the purpose of providing a linear time base for a cathode-ray oscilloscope and capable of operating at frequencies well below those at which the sweep in the ordinary oscilloscope becomes useless. *E.P.C.*

James Hubert Noland, Jr., *Performance Curves of a Double-Cage Induction Motor*. Faculty advisor: Professor D. P. Savant.

It is very desirable to be able to predict the operating characteristics of electrical machinery from tests which do not require a great amount of power. With most apparatus, little difficulty in doing this is encountered, but the double squirrel-cage induction motor, with its many variable elements, poses a somewhat greater problem. The purpose of this investigation was to set forth several methods of obtaining a current diagram for the double-cage motor analogous to the circle diagram for the normal three-phase motor; to obtain from the current diagram the desired operating characteristic curves; and to compare the merits of the various methods used.

The author reviewed the existing literature and concluded that very little work has been done on an actual mathematical analysis of the double-cage machine. Based on the previous work of Voigt,<sup>1</sup> the basic constants of a three-phase, double-cage, 7.5 hp induction motor was determined. Current diagrams were then drawn and the performance curves predicted, using several different methods. These predicted values were checked against an actual brake test on the motor, and, at large slips, check values were obtained by measuring instantaneous values of current and slip during starting and coming up to speed. Predicted and actual values were compared graphically. Due to a nonuniformity in the meaning of symbols found in the literature, it was necessary for the author to devise his own system, which agrees insofar as possible with accepted American notations.

The results obtained were analyzed by the author, who concluded that the values predicted by the use of exact equivalent circuits gave results that were as accurate as those obtained with the brake test. The values predicted by using the approximate equivalent circuit method were considered to be of sufficient accuracy for most uses, while the AIEE method gave variable results. *E.P.C.*

<sup>1</sup> Hans Karl Voigt, "Die Trennung der Widerstände eines Doppelhafig-Ankers," *Elektrotechnik und Maschinenbau* 50, 133-35 (1932).

## GEORGIA INSTITUTE OF TECHNOLOGY

Donald Spencer Powell, *High Frequency Performance of Parallel-T Networks*. Faculty advisor: Professor M. A. Honnell.

The parallel-T network, consisting of resistive and capacitive elements, has been a subject of widespread investigation and application in recent years for selective feed-back in vacuum tube amplifiers. A critical review of previous investigations of R-C parallel-T networks indicates that the transfer characteristics have not been experimentally determined at high frequencies, i.e., in the 15-kilocycle to 500-kilocycle range. Therefore, the purpose of this investigation was to extend the study of voltage transfer characteristics to supersonic and higher radio frequencies.

The author simplified the experimental work by selecting a relatively high frequency within the specified range on the premise that satisfactory performance would lead to a logical conclusion at lower frequencies. A mathematical analysis of the characteristics of the symmetrical network is presented and then, extended to unsymmetrical configurations to establish null criteria in terms of the symmetry and shunt arm parameters. The experimental work, which consisted of the testing of networks as separate units to determine null frequencies and the individual attenuation characteristics, is described. The results of the experimental work are presented in the form of frequency response curves for individual networks and for the two-stage resistance-capacitance coupled feed-back amplifier employing parallel-T networks having a null frequency of 450 kilocycles. After a careful review of these results, the author concludes that when the parallel-T network is used in the feed-back circuit of a resistance-coupled amplifier operating at 450 kilocycles, a high degree of selectivity can be obtained when network design parameters are carefully chosen and the over-all gain of the amplifier is maintained at a relatively high level. *E.P.C.*

Frank Montague Tuttle, Jr., *The Design and Construction of a Frequency Standard System*. Faculty advisor: Dr. W. A. Edson.

Development in communication engineering depends largely upon precise measurements. In order that these may be made, standards must be available that are accurate to a

degree equal to or better than the measurements to be made. One of the most important standards is that of frequency. The primary objective of this thesis was the design and construction of a frequency standard which would have a stability approaching one part in a million for use in the electronics laboratory of the School of Electrical Engineering of the Georgia Institute of Technology. A secondary objective consisted in the development of a counting device suitable for comparing the frequency of this standard with that of the frequency standard of the National Bureau of Standards.

The author describes the basic circuit selected, the frequency measuring system devised, and various methods that might be employed in the calibration of such a system. The experimental results obtained are discussed, including a number of experimental difficulties encountered during the course of the investigation. *E.P.C.*

Vernon Roberts Widerquist, *A Series Resonant Crystal Controlled Oscillator*. Faculty advisor: Dr. W. A. Edson.

The use of quartz crystal resonators to provide a high degree of frequency stability in oscillators is a well recognized and widely used practice. The excellent frequency control which a crystal exhibits is due to its extremely high Q as a mechanical resonator and, through the piezoelectric effect, as an electrical resonator. The purpose of this study was to devise and to investigate an oscillator circuit which would take advantage of the properties of a crystal operating at series resonance and also produce proper impedance levels for both the crystal and the vacuum tube.

The author discusses the basic circuit required to accomplish the purpose of his investigation and describes the conditions for operation of such a circuit. The synthesis of a suitable network is traced, including the transformation of the low-pass network into an impedance transforming band pass network. The author concludes with a discussion of a practical oscillator and notes that the particular circuit that was developed was only one of many possible solutions to the original problem.

*E.P.C.*



## SOME SPECIAL ASPECTS OF TELEVISION

*Continued from Page 4*

elaborate air-conditioning facilities had to be installed in the pressurized radio compartment of the plane, because of the great amount of heat generated by the radio equipment, although the ambient temperature at 25,000 feet is usually below 0° F.

It has been shown that Stratovision is practical from a technical standpoint. It appears, however, that Stratovision broadcasting would have to be assigned to the 475- to 890-megacycle television band now being studied by the FCC, since there are not enough channels available for this service in the present band. The research information resulting from the Stratovision project is a definite contribution to the field of radio propagation and airborne radio broadcasting.

**MILITARY AIRBORNE TELEVISION**

During the war, RCA and NBC developed several versions of a compact airborne television transmitting and receiving set to be used for reconnaissance purposes and in television-guided, radio-controlled glide bombs. Since over 4,000 of these units were manufactured, the potentialities of television for combat purposes were well demonstrated before the end of the war. The two basic television systems developed were given the pseudonyms of "Block" and "Ring" for security purposes.

One model of the Block television transmitter operated on a frequency in the 300-megacycle band with an unmodulated output power of 15 watts. The camera unit employed sequential scanning with a rate of 40 frames per second and produced 350 lines. Later versions of this complete transmitter and camera weighed around 50 pounds.

The Block system was installed in several types of radio-controlled glide bombs and "war-weary" B-17 and B-24 planes which were loaded with explosives and crashed into enemy targets. These missiles were controlled from a "mother" plane, where a control pilot continuously studied the image of the target on the television receiver screen in order to guide the bomb straight to its objective.

The Ring system developed for the Navy used interlaced scanning with a field frequency of 40 per second and a frame frequency of 20 per second. This system produced a total of 567 lines. The Ring transmitter had a power output of approximately 1,000 watts in the 100-megacycle band. The excellent resolution and high power of the Ring television system rendered it particularly useful for reconnaissance work. It was installed in radio-controlled pilotless planes which were sent over enemy territory, one camera being installed in the nose of the plane and another in the waist. Scenes picked up by this airborne television system were immediately visible in remote reception centers.

Block and Ring systems were also used to direct pilotless crash boats loaded with explosives against enemy targets, for observation of gunfire, in map making, for observation of dangerous operations from a protected area, and for reading instruments in connection with critical testing of aircraft. Television made available eyewitness information from places unsafe for personnel.

**TELEVISION AT BIKINI**

One of the most interesting uses of the Block television equipment was in connection with the atom bomb tests at Bikini. Two television cameras were installed on 75-foot towers spaced a half-mile apart approximately three miles from the center of the target area. Receivers were installed in several ships and planes. Some of the receivers were equipped with cameras in order that a semicontinuous record could be made of the images on the screens.

Another completely separate television system was installed on pilotless airplanes which were flown over the center of the explosion and through the atomic cloud column. Monitoring receivers were installed in the "mother" planes. Although the scenes reproduced by this television system were not as clear as those which would have been obtained by direct vision, no one would have voluntarily exchanged places with the television cameras.

### UNDERWATER USE OF TELEVISION

During the summer of 1947, naval airborne television equipment employing a sensitive image orthicon tube was installed in a water-proof steel cylindrical container and was lowered to depths as great as 180 feet at Bikini for the purpose of examining underwater objects. The results of these tests were quite successful.

Suggested uses for the underwater television are for the examination of sunken ships in salvage work, for the examination of the bottom of harbors and ship channels, in the study of marine life at depths not previously penetrated by man, and in connection with underwater construction projects.

The equipment for this type of application of television is quite simple, since the television transmitter and receiver and their associated antennas are not needed. The television camera is connected through a coaxial cable and a multiwire power cable to the receiving monitor.

### TELERAN

An important application of television to air navigation now undergoing development is known by the name of Teleran, which is a contraction of *Television-Radar Air Navigation*. In this system, a radar transmitter on the ground collects information concerning the position of aircraft within a 50-mile radius and displays the relative positions of these aircraft on the screen of a cathode ray tube in the form of bright elongated spots. A television transmitter transmits significant portions of this information along with a map of terrain features, meteorological data, or a pictorial map of landing instructions to a television receiver mounted on the instrument panel in the plane.

The important features of Teleran are that the pilot sees a continuous picture showing the position of his plane relative to all other planes flying at the same altitude superimposed on a map with complete flight lane markings, weather data, and other information important to his flight. Teleran may some day provide the solution to reliable all-weather flying.

### EDUCATIONAL USES

Television has been used on an experimental basis in hospitals to permit a large audience of surgeons and medical students to obtain a close-up view of delicate operations while they were in progress. This new viewing technique may prove to be very valuable in the field of surgical teaching, especially when color television with its improved resolution is generally available.

During January, the Navy telecast lectures over a four-mile microwave link to television receivers at the Merchant Marine Academy in order to compare television with conventional teaching techniques. Television will permit the Navy to bring scenes aboard ship and in submarines directly to the classroom.

The potentialities of television as an educational medium are unlimited. However, the present limited network facilities and the high cost of television will place it out of the reach of most school systems for many years to come.

Nevertheless, television, even as presently practiced, will prove to be a forceful educational medium which will materially raise our standard of living, because it will bring into the home many programs of cultural and educational value.

### PROJECTION TELEVISION

Large-screen television projection equipment has opened up many new possibilities for television in theatres and department stores, and for overflow audiences at night clubs and athletic events. Projectors now available are capable of throwing a picture as large as 15 by 20 feet.

These projectors utilize a 15-inch cathode-ray tube operating at 80,000 volts, in conjunction with a special high-efficiency reflective optical system consisting of a 42-inch spherical mirror and a 36-inch aspherical correcting lens. A color television projector which projects a 7.5- by 10-foot picture has also been demonstrated. This projector makes use of three cathode-ray tubes, each with its own optical system, in order to project simultaneously the green, blue, and red images which combine to produce a full-color picture.

### CONCLUSIONS

Television provides one of the most powerful means of communication and broadcasting that has yet become available to the general public. Although the resolution of television broadcasting equipment is necessarily limited by regulations in order to protect both manufacturer and consumer from too rapid obsolescence of equipment, there are no similar restrictions for many industrial television applications. Television systems which do not require a radio link do not fall under the jurisdiction of the FCC. These systems, therefore, may have a higher than standard resolution, or may even employ full color.

Simplified television equipment has already been announced by Remington Rand for interoffice use. This Vericon equipment is a commercial development resulting from airborne equipment which Rand manufactured during the war for the Air Force.

Television is certain to become one of the big industries of this country. From now on, television will find more and more fields of application in industry, for it has definitely passed the stage of being "just around the corner."

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## GEORGIA TECH AND THE OAK RIDGE INSTITUTE

*Continued from Page 8*

in research programs of the institute. Needless to say, all of the fields of research listed as being available to graduate students are open to faculty members. It is anticipated that at least one member of the Georgia Tech faculty will spend some time at Oak Ridge during this year.

A number of lecturers from Oak Ridge are scheduled to appear before Georgia Tech audiences during the next few months. The visits of these scientists and engineers to the campus is one of the most concrete evidences of the participation of Georgia Tech in the activities of the Oak Ridge institute since

their lectures are open to all interested students and faculty members. This program was actually initiated during the latter part of 1948 by the visit of Dr. Weinberg, Director of the Physics Division of the Oak Ridge National Laboratory, who delivered a lecture on the subject of "Physics Research at Oak Ridge."

As yet, little progress has been made in establishing research projects at Georgia Tech in either nuclear or allied fields. This is primarily occasioned by the stringent security regulations which surround many nuclear problems and by the necessity for classifying

## GEORGIA INSTITUTE OF TECHNOLOGY

the various research fields prior to the establishment of actual research projects.

In any cooperative venture, and particularly in one as large and as complex as the Oak Ridge institute, many obstacles must be overcome. Naturally, all of these obstacles have not been surmounted in the relatively short span of time that the institute has been in operation. However, sufficient progress has been made to indicate that the association with the highly trained personnel of Oak Ridge will be extremely valuable to the faculty and students of

Georgia Tech and that the use of facilities which were hitherto unavailable will be of immeasurable benefit in the development of Georgia Tech's research program. It is also anticipated that Georgia Tech's development through participation in this program will be of material benefit to Georgia as well as to the South and that, through the mutual cooperation of the Southern universities involved, the name Oak Ridge will eventually cease to become synonymous with the atomic bomb and will instead be recognized as the location of one of the South's greatest research establishments.

### HIGH-SPEED TEMPERATURE RECORDER

*Continued from Page 6*

out the a-c component from the output of the "Autopot," and the 5200-ohm resistor across this circuit is employed to provide critical damping for the recorder.

The variable resistor shown in Figure 1 determines the sensitivity of the response of the "Autopot." The manufacturer furnishes standard resistors in such values that the

response of the instrument is 100 microvolts, 1 millivolt, 10 millivolts, 100 millivolts, or 1 volt, depending upon which resistor is plugged into the "Autopot." When used with copper-constantan thermocouples and a C-1 milliammeter, these response values correspond to full-scale deflection equivalent to approximately 1° F.

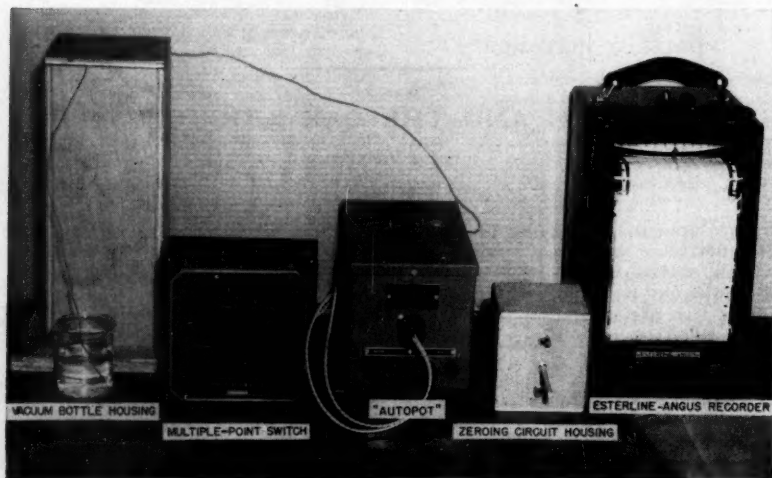


Figure 2. Temperature recording system.

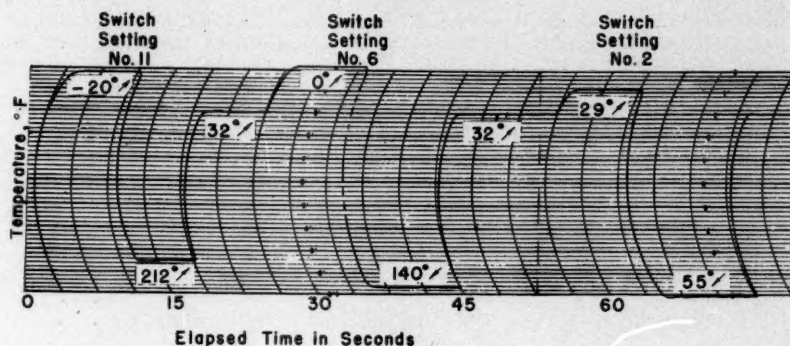


Figure 3. Time response curves drawn by the Esterline-Angus recorder.

to 1000° F. In using this instrument with copper-constantan or chromel-alumel thermocouples and a C-1 milliamperere recorder, it was found advantageous to construct a variable resistance in place of these standard resistors, so that the temperature range of full-scale deflection on the recorder could be controlled more easily. This was done by taking a 12-point switch and wiring lengths of No. 24 constantan wire equivalent to 0.500-ohm resistance between each of the first 11 points of the switch. The switch was then connected to the "Autopot" by short lengths of No. 12 copper wire. In this manner, the resistance across the input to the "Autopot" can be varied from 0.500 ohm to 5.000 ohms in 0.500 increments as the switch knob is rotated from the No. 2 position to the No. 11 position.

#### OTHER COMPONENTS

This switch is shown with the other components of the temperature recorder system in Figure 1, as well as in Figure 2. Also shown in Figure 2, from left to right, are the housing for the vacuum bottle which is used for the reference couple, the multiple-point switch, the "Autopot," the box containing the zeroing circuit, and the Esterline-Angus recorder.

In Figure 3 are shown several time response curves drawn by the Esterline-Angus recorder at a chart speed of 0.2 inch per second. These curves illustrate the versatility in recording temperature changes of the equipment shown in Figure 2. In each case

the response of a chromel-alumel thermocouple of No. 30 wire is shown for various settings of the variable resistor switch. The reference couple was immersed in an ice bath, and this temperature was set at 0.2 milliamperere on the recorder chart. The curves shown in Figure 3 were drawn by the Esterline-Angus recorder when the variable resistor of the "Autopot" was set at switches 11, 6, and 2, as indicated in Figure 3, and the thermocouple was immersed first in a cold solution and then in a warm solution. Examination of the time response shown by these curves indicates that the response time of the entire system, including the thermocouple, is about 1.5 seconds for full-scale deflection. It can also be seen that the temperature equivalent of full-scale can be changed from 279° F. (5.78° F. per division below 32° F.; 5.54° F. per division above 32° F.) to 27.8° F. (0.50° F. per division below 32° F.; 0.57° F. per division above 32° F.) by changing the switch setting of the variable resistor for the "Autopot." It is obvious that other resistor values could be employed to obtain other temperature ranges. In addition to changing the variable resistor, the zeroing circuit was employed in locating 32° F. at 0.2 milliamperere when the sensitivity of the "Autopot" was increased greatly.

The characteristics illustrated in Figure 3 have been found to be extremely useful for recording the temperature changes indicated by small thermocouples in the very



rapid freezing of small objects, for recording the temperature fluctuations of freezing baths over a period of hours, and for recording temperature changes which take place in a few minutes. In each case, a simple change in chart speed or of the variable resistor for the "Autopot" was all that was required to obtain a curve having the desired characteristics. This high degree of versatility has made this system extremely useful for so many purposes that its range of application to the recording of temperatures

seems almost unlimited. In addition, each of the two components of the system — the "Autopot" and the Esterline-Angus C-1 milliampererecorder—has separate applications to many other problems and, when properly used, is itself an extremely versatile tool.

## ACKNOWLEDGMENT

Acknowledgment is gratefully made to Dr. F. Bellinger, director of this project, for his advice and guidance.

## ANTIOXIDANTS FOR OILS AND FATS

Continued from Page 12

one set of experiments, however, four samples of prime steam lard containing 0.1 per cent by weight of four different antioxidants were compared with four untreated samples of the same lard. The most effective antioxidant tested was propyl gallate; the sample treated with this antioxidant required an exposure of 135 days at 140° F. before rancidity became apparent, whereas the control sample was rancid at the end of seven days. Results obtained under the same conditions with the other antioxidants were: tocopherol: treated = 18 days, untreated = 4 days; gum guaiac: treated = 23 days, untreated = 7 days; and wheat germ oil derivative: treated = 6 days, untreated = 5 days.\*

Antioxidants are also effective in protecting an oil or fat even after it has been incorporated in foods; in one instance, the estimated shelf life of potato chips was increased approximately eight-fold by the addition of a very small quantity (0.01 per cent by weight) of an antioxidant to the frying medium.

Thus, the processors of oil- and fat-containing foods are given a powerful tool in their never-ending fight to obtain and to retain customer acceptance of their products.

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## SUBJECT INDEX

A subject index to the first three volumes of THE RESEARCH ENGINEER (1946-47, 1947-48, and 1948-49 volumes) will appear in the May, 1949, issue. This index will be printed in such a manner that it can be separated from the May issue and bound with the previous volumes, if so desired.

In future years, it is planned that a subject index will be prepared separately for each annual volume, but this was not practical in the present instance. Pagination in future volumes will be consecutive from issue to issue.

